CLAIMS

1. A broadband wavelength multiplexing and demultiplexing filter comprising:

Mach-Zehnder optical interferometer circuits each having directional couplers formed on a substrate by a first optical waveguide and a second waveguide provided in parallel to each other with a gap in a lengthwise direction of the optical waveguides therebetween, and a phase part interposed between the directional couplers;

a first point-symmetrically connected optical interferometer circuit formed by accurately point-symmetrically connecting two equal Mach-Zehnder optical interferometer circuits in series; and

a light input side circuit formed by connecting one or more first point-symmetrically connected optical interferometer circuits in series;

wherein a light input terminal of a first optical waveguide of the light input side circuit is composed of an input port for optical signals having a plurality of wavelengths, and an output terminal of the first optical waveguide is composed of a through port,

an output terminal of a second optical waveguide of the light input side circuit is composed of a cross port,

a first light output side circuit formed by serially connecting one or more second point-symmetrically connected

optical interferometer circuits having the same functional structure as the first point-symmetrically connected optical interferometer circuit is connected to the through port, and

a second light output side circuit including one or more Mach-Zehnder optical interferometer circuits having transmission characteristics different from those of the Mach-Zehnder optical interferometer circuits constituting the first and the second point-symmetrically connected optical interferometer circuits is connected to the cross port.

2. The broadband wavelength multiplexing and demultiplexing filter according to claim 1,

wherein the second light output side circuit has n-stage (where n is an integral number equal to or greater than 2) Mach-Zehnder optical interferometer circuits,

a light output side of a second optical waveguide of a previous-stage Mach-Zehnder optical interferometer circuit is connected to a light input side of a first optical waveguide of the next-stage Mach-Zehnder optical interferometer circuit, that is, a light output side of a second optical waveguide of a first-stage Mach-Zehnder optical interferometer circuit is connected to a light input side of a first optical waveguide of a second-stage Mach-Zehnder optical interferometer circuit,

a light input side of a first optical waveguide of the first-stage Mach-Zehnder optical interferometer circuit is connected to a cross port of the light input side circuit, and

a light input side of a first optical waveguide of the first light output side circuit is connected to a through port of the light input side circuit.

3. The broadband wavelength multiplexing and demultiplexing filter according to claim 2,

wherein the second light output side circuit has a third point-symmetrically connected optical interferometer circuit having the same functional structure as the first point-symmetrically connected optical interferometer circuit.

4. The broadband wavelength multiplexing and demultiplexing filter according to claim 2 or 3,

wherein optical signals output from the through port among a plurality of wavelengths input to the light input terminal of the first optical waveguide of the light input side circuit are output from the light output side of the first light output side circuit through the first optical waveguide thereof, and

the optical signals output from the cross port of the light input side circuit among the plurality of wavelengths are input to a first optical waveguide of a first-stage circuit of n-stage connection circuits constituting the second light output side circuit and are then output from a light output side of a second optical waveguide of the last-stage circuit.

5. The broadband wavelength multiplexing and demultiplexing filter according to claim 1,

wherein, when the optical signal input to one of the first

optical waveguide and the second optical waveguide and then output from the one optical waveguide is referred to as a through propagating optical signal, and when the optical signal input to one of the first optical waveguide and the second optical waveguide and then output from the other optical waveguide is referred to as a cross propagating optical signal,

the point-symmetrically connected optical interferometer circuit has one or more low through loss wavelength bands where a loss of the through propagating optical signal is low, and

at least one of the Mach-Zehnder optical interferometer circuits constituting the second light output side circuit is constructed such that a loss of the cross propagating optical signal has a maximum value in at least one of the low through loss wavelength bands.

6. The broadband wavelength multiplexing and demultiplexing filter according to claim 5,

wherein the point-symmetrically connected optical interferometer circuit has one or more low cross loss wavelength bands where a loss of the cross propagating optical signal is low, and

at least one of the Mach-Zehnder optical interferometer circuits constituting the second light output side circuit is constructed such that a loss of the through propagating optical signal has a maximum value in at least one of the low cross

loss wavelength bands.

7. A broadband wavelength multiplexing and demultiplexing filter comprising a plurality of the broadband wavelength multiplexing and demultiplexing filters according to claim 1 provided on a substrate in an array shape.

8. A broadband wavelength multiplexing and demultiplexing filter comprising:

Mach-Zehnder optical interferometer circuits each having two directional couplers on a substrate, each directional coupler formed by a first optical waveguide and a second optical waveguide provided in parallel to each other with a gap therebetween, and

a phase-part-intervention-type point-symmetrically connected optical interferometer circuit formed by point-symmetrically arranging two equal Mach-Zehnder optical interferometer circuits in series and connecting them to each other with a phase part for generating a predetermined phase change interposed therebetween,

two equal phase-part-intervention-type point-symmetrically connected optical interferometer circuit being accurately point-symmetrically connected in series,

wherein the Mach-Zehnder optical interferometer circuits have equal directional couplers, and these directional couplers are connected in series to each other with a second phase part for generating a phase change different from that in the phase

part interposed therebetween.

9. The broadband wavelength multiplexing and demultiplexing filter according to claim 8,

wherein a light input terminal of a first optical waveguide of a phase-part-intervention-type point-symmetrically connected optical interferometer circuit is composed of an input port for optical signals having a plurality of wavelengths, and an output terminal of the first optical waveguide is composed of a through port,

an output terminal of a second optical waveguide of the phase-part-intervention-type point-symmetrically connected optical interferometer circuit is composed of a cross port, and

one or more phase-part-intervention-type point-symmetrically connected optical interferometer circuits having the same structure are connected in series to the through port.

10. The broadband wavelength multiplexing and demultiplexing filter according to claim 9,

wherein an optical signal input to an input port and then output from the through port passes through only the optical waveguide at the through port side of each phase-part-intervention-type point-symmetrically connected optical interferometer circuit.

11. The broadband wavelength multiplexing and

demultiplexing filter according to claim 9,

wherein one or more phase-part-intervention-type point-symmetrically connected optical interferometer circuits having the same structure and one or more filter circuits for improving isolation of the optical signal output from the cross port are connected in series to the cross port of the phase-part-intervention-type point-symmetrically connected optical interferometer circuit.

12. The broadband wavelength multiplexing and demultiplexing filter according to claim 11,

wherein the filter circuit comprises a second directional coupler and a third phase part connected in series to each other,

the second directional coupler is different from the directional coupler of the phase-part-intervention-type point-symmetrically connected optical interferometer circuit in coupling efficiency, and

the third phase part is different from the second phase part in length (phase amount).

13. The broadband wavelength multiplexing and demultiplexing filter according to claim 11,

wherein the optical signal input to the input port and then output from the cross port passes through only the optical waveguide at the cross port side of each phase-part-intervention-type point-symmetrically connected optical interferometer circuit.

14. The broadband wavelength multiplexing and demultiplexing filter according to claim 11,

wherein a wavelength band where a transmittance of the filter circuit provided at the cross port side is decreased to form a valley-shaped spectrum is equal to a wavelength band where a transmittance of the phase-part-intervention-type point-symmetrically connected optical interferometer circuit provided at the through port is decreased to form a valley-shaped spectrum.

15. The broadband wavelength multiplexing and demultiplexing filter according to claim 11,

wherein a wavelength band where a transmittance of the filter circuit provided at the cross port side is decreased to form a valley-shaped spectrum is equal to a wavelength band where a transmittance of the phase-part-intervention-type point-symmetrically connected optical interferometer circuit provided at the through port is increased to form a mountain-shaped spectrum.

16. A broadband wavelength multiplexing and demultiplexing filter comprising a plurality of the broadband wavelength multiplexing demultiplexing filters according to claim 9 or 10 provided on a substrate in an array shape.

17. An optical splitter with an optical signal multiplexing and demultiplexing function comprising:

an optical waveguide circuit formed on a substrate,

wherein the optical waveguide circuit comprises:

an optical splitter for splitting an optical signal input from a light input port provided at one end of the optical waveguide circuit into a plurality of optical signals having the same intensity and for outputting them from a plurality of light output ports; and

a plurality of optical signal multiplexing and demultiplexing devices arranged in parallel to each other, each being provided with two light input ports and having a function of multiplexing optical signals having different wavelengths input from the light input ports,

wherein one input port of each of the optical signal multiplexing and demultiplexing devices is connected to the corresponding light output port of the optical splitter,

the other light input port of each of the optical signal multiplexing and demultiplexing devices is provided at one end side of the optical waveguide circuit to be parallel to the light input port of the optical splitter, and

a multiplexed optical signal output port of each of the optical signal multiplexing and demultiplexing devices is provided at an end portion side other than a region where the light input port of the optical waveguide circuit is provided.

18. The optical splitter with an optical signal multiplexing and demultiplexing function according to claim 17, further comprising:

a first optical waveguide and a second optical waveguide provided in parallel to the first optical waveguide with a gap therebetween,

wherein two Mach-Zehnder optical interferometer circuits, each having directional couplers formed by arranging the first and the second optical waveguides closely to each other with a gap in a lengthwise direction of the optical waveguides therebetween, are connected in series to each other to form an optical signal multiplexing and demultiplexing device,

an arrangement pitch between the directional couplers in one Mach-Zehnder optical interferometer circuit is equal to that in the other Mach-Zehnder optical interferometer circuit,

a length of a phase part of the first optical waveguide is larger than that of the second optical waveguide by a set length, in the one Mach-Zehnder optical interferometer circuit, and

a length of a phase part of the second optical waveguide is larger than that of the first optical waveguide by the set length, in the other Mach-Zehnder optical interferometer circuit.

19. The optical splitter with an optical signal multiplexing and demultiplexing function according to claim 18,

wherein, when a coupling efficiency of one directional

coupler in the Mach-Zehnder optical interferometer circuit is K, a differential coefficient $dK/d\lambda$ of the coupling efficiency K with respect to a wavelength of 1.55 μm is negative, and the coupling efficiency K is about 100% at a wavelength of 1.31 μm.

20. The optical splitter with an optical signal multiplexing and demultiplexing function according to claim 17 or 18,

wherein the optical signal multiplexing and demultiplexing device has a function of multiplexing and demultiplexing optical signals in a wavelength band of 1.31 μm, a wavelength band of 1.49 μm, and a wavelength band of 1.55 μm.